

Physiological weight loss in the breastfed neonate: a systematic review

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ABSTRACT

Background: Healthy, full-term, exclusively breastfed infants are expected to lose weight in the first days following birth. There are conflicting opinions about what constitutes a normal neonatal weight loss, and about when interventions such as supplemental feedings should be considered.

Objective: To establish the reference weight loss for the first 2 weeks following birth by conducting a systematic review of studies reporting birth weights of exclusively breastfed neonates.

Methods: We searched 5 electronic databases from June 2006 to June 2007: the Cochrane Database of Systematic Reviews; MEDLINE (from 1950); CINAHL (from 1982); EMBASE (from 1980); and Ovid HealthSTAR (from 1999). We included primary research studies with weight loss data for healthy, full-term, exclusively breastfed neonates in the first 2 weeks following birth.

Results: Eleven studies met the inclusion criteria. Definitions, types of measurements, and reporting styles varied among studies. In most studies, daily weights were not measured and measurements did not continue for 2 weeks. Mean weight loss ranged from 5.7% to 6.6%, with standard deviations around 2%. Median percentage weight loss ranged from 3.2 to 8.3, with the majority around 6%. The majority of infants in these 11 studies regained their birth weight within the first 2 weeks postpartum. The second and third days following birth appear to be the days of maximum weight loss.

Discussion: Methods used to report weight loss were inconsistent, using either an average of single lowest weights or a combination of weight losses. The 7% maximum allowable weight loss recommended in 4 clinical practice guidelines appears to be based on mean weight loss and does not account for standard deviation. Further research is needed to understand the causes of neonatal weight loss and its implications for morbidity and mortality.

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INFANT WEIGHT MEASUREMENT IS ONE OF THE TOOLS most frequently used to assess breastfeeding adequacy. Neonates receive only small amounts of fluids in the first days following birth,¹ and they tend to lose weight before they begin to gain weight.² Excessive weight loss or inadequate weight gain can be indications of low milk production or of insufficient milk transfer. To ensure adequate intake and, at the same time, to avoid inappropriate supplementation, parents and professionals need evidence to assess patterns of neonatal weight change and to make decisions about infant feeding.

Expert opinions and guidelines disagree about what constitutes a normal neonatal weight loss. How much weight loss should be considered a red flag? What is the upper limit that indicates intervention is required? We did a systematic review to answer the question, “What is a normal physiological weight loss for full-term exclusively breastfed infants in the first 2 weeks following birth?”

We made 3 assumptions. First, neonatal weight loss in the first days following birth is expected, and we therefore refer to such weight loss as physiological weight

loss. Second, to define abnormal or pathological weight loss, we need evidence of what would be considered a normal or reference weight loss. Third, we expected to find observational studies (e.g., cohort, case-control) rather than randomized controlled trials (RCTs) in our search. The nature of the research question and the implications of the answer for the care of breastfed infants require a rigorous methodology. Therefore, we chose to complete a systematic review even though we sought evidence for parameters of weight loss and not for optimal interventions.

Methods

Search methods. Two of us (JNW, GC) completed separate database searches through our respective university libraries. We searched 5 electronic databases from June 2006 to June 2007: the Cochrane Database of Systematic Reviews, MEDLINE (from 1950); CINAHL (from 1982); EMBASE (from 1980); and Ovid HealthSTAR (from 1999). Boolean searches using alternative spellings of key words were run multiple times (see Textbox 1). Boolean searches were also completed using Google and Scirus search engines. We identified relevant clinical practice guidelines (CPGs) and used their reference lists to ensure a thorough search. We did not restrict our search by dates, study design (all research methods were considered), language, or country of origin.

Inclusion criteria. We included only primary research studies that reported data about weight loss occurring in the first 2 weeks following birth. We defined primary research as research undertaken by the authors, and we included systematic reviews and secondary analyses of data sets. The “primary research” criterion allowed for the inclusion of research studies that collected data about weight loss as part of their protocol, even if their research was not intended to be about weight change patterns. We excluded cited research, narrative reviews, and reports that did not measure and report individual weight loss.

We included studies of healthy, full-term, singleton, breastfed babies. We defined full-term as a gestation of more than 259 days (36 6/7 weeks),³ and we defined breastfeeding (i.e., exclusively breastfed) as fed only breast milk, whether at breast or by bottle, with no other food or liquids, including water, with the exception of medicines, vitamins or minerals.⁴ We excluded studies of infants fed or supplemented with formula, and pre-term, near-term, or multiples (e.g., twins, triplets), unless data for full-term, singleton, exclusively breastfed infants were reported separately.

Textbox 1: Basic search string for this systematic review

1. (infant or neonate or newborn or baby or neonatal).mp.
[mp=ti, ot, ab, nm, hw]
2. (breastfeeding or breast-feeding or breast feeding).mp.
[mp=ti, ot, ab, nm, hw]
3. (full-term or fullterm or term).mp. [mp=ti, ot, ab, nm, hw]
4. (weight or weight loss or “birth weight” or birth weight).mp.
[mp=ti, ot, ab, nm, hw]
5. (postnatal or post natal).mp. [mp=ti, ot, ab, nm, hw]
6. weight.m_titl.
7. 4 or 5 or 6
8. 1 and 2 and 3 and 7

Note: “mp.” indicates that a term was searched as a key word (including ti = title, ab = abstract; nm = name of substance word, etc.), whereas “m_titl.” indicates it was searched for in titles only

Data abstraction and analysis. We conducted separate searches and abstractions. First, articles were screened and retrieved based on their titles and abstracts (see Fig. 1 for methodological steps). In the next step, 2 of us (JNW, GC) used an abstraction form developed for this systematic review to analyze screened studies to determine eligibility for inclusion. Results were compared to reach a consensus. Six authors were contacted for clarification.^{5–10}

We constructed tables and examined key aspects of each study: research design, population size, types and timing of data collection, methods for measurement, definitions of breastfeeding, and elements of reporting. We used descriptive statistics from the studies. In one case, to answer the research question, we had to re-analyze data in order to pool the study subjects to obtain an average for the whole group.¹¹

Results

Eleven studies met the inclusion criteria (see Table 1).^{6–8,11–18} Ten of the studies were observational. One study, an RCT,¹² provided data from the control arm that we used. With one exception, all were prospective studies in which data were collected on the basis of a research question. The one exception was a secondary analysis of data.¹⁴ Six of the 11 studies researched non-weight topics but provided data about weight change patterns. Nine of the studies were reported in English, one in French, and one in Croatian. Studies were conducted in Bangladesh, France, India, Italy, Jamaica, Scotland, Serbia, Spain, Sweden, and the United States.

Authors of the included studies reported the amount and timing of weight loss using a variety of descriptive

statistics (see Table 1, under Study Results). None of the studies provided morbidity or mortality statistics. Examples of excluded studies and rationales for their exclusion are provided (see Table 2).^{5,9,10,19–29}

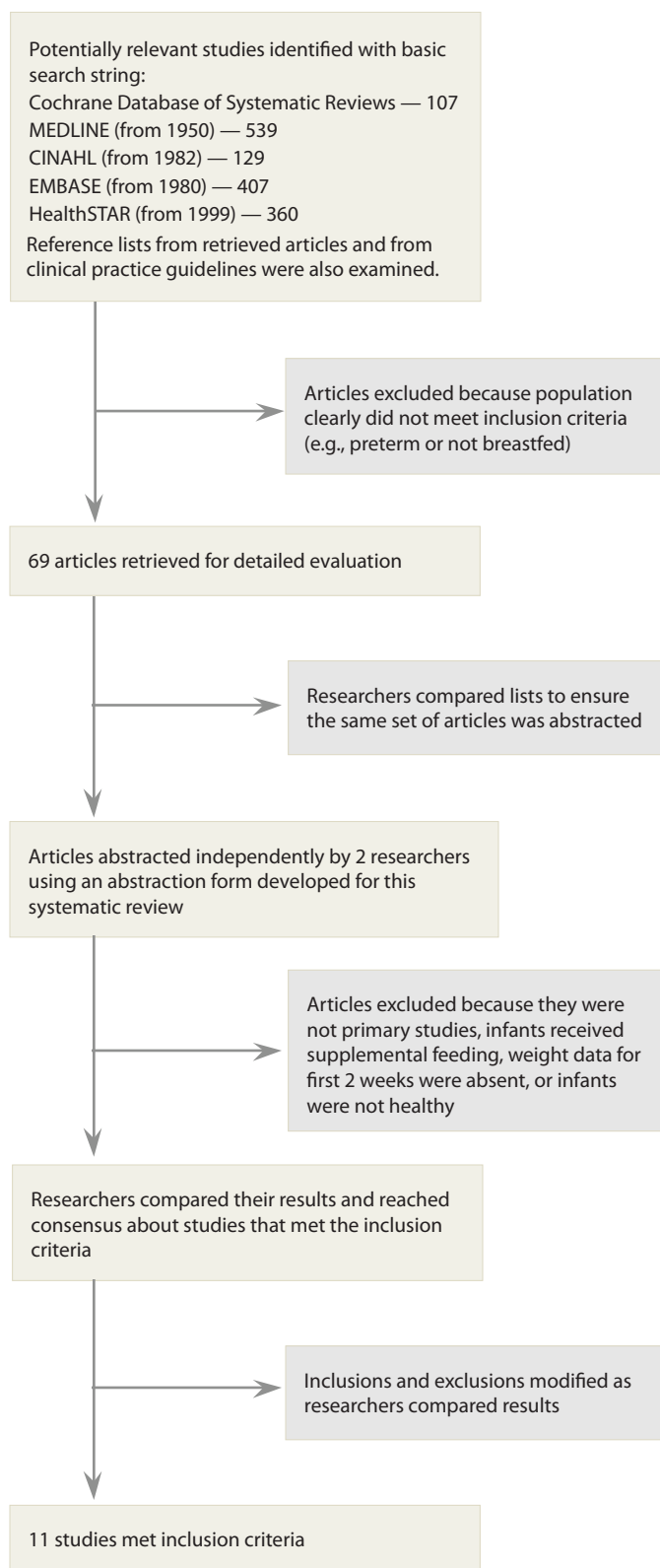


Figure 1: Methodological steps

Appraisal of included studies. The studies included in this review represented several different cultures. In all studies, measurements started from birth. The populations were comparable in age, but the length of time for and frequency of weight measurements were not comparable across studies. Sample sizes varied from 21 to 937, with a median of 120. All but one study had more than 40 subjects. Most studies had convenience, not random, samples.

Measurement bias occurred in many of the studies that met the inclusion criteria. The frequency of weighings was inadequate. Most of the studies weighed the infants daily while they were in hospital, but not after discharge. The lack of measurements makes determining lowest weight and normal patterns of weight loss impossible. The fact that most of the research studies were not primarily intended to study weight explains some of the variations. In one study, researchers completed a secondary analysis of data and reported maximum weight loss, even though infants were weighed only twice over a 2-week period.¹⁴ With only 2 weights measured in 2 weeks, it is not possible to determine the lowest weight, or when it was reached.

Definitions for breastfeeding and weight loss, as well as inconsistencies in approaches and reporting methods for descriptive statistics, were problematic. Most studies did not specify a definition of breastfeeding. In 1 case, the term “exclusively breastfed” was used, but later in the report we found that infants who received water or glucose water were included.¹⁰ Neonates frequently had substantial weight loss, in which case supplementation might be expected, but researchers rarely identified when the infants received supplemental feeding. Without a clear definition of breastfeeding, and without clear reporting of supplementation, it is difficult to discern supplemented from exclusively breastfed neonates (i.e., nothing by mouth except breast milk and, possibly, medicines or vitamins). We contacted authors to establish the definition of breastfed infants in their studies, and we only included study data that met our definition.

Definitions of weight loss varied. Maximum weight loss for an infant could be the lowest single weight or it could be an average of the daily losses. Furthermore, a mean loss for the study group could be each infant’s one lowest weight, pooled and averaged, or all of the infants’ weight losses averaged for the group. The size of the sample often varied within a study (i.e., smaller sample on day 3 than on day 1) due to attrition and this fact complicates calculations of mean weight loss.

There are some inconsistencies as to whether the day of birth was counted as day 0 or day 1, a detail that may cause confusion with regard to expectations as to when

Table 1: Studies that met the inclusion criteria

Reference	Methodology	Purpose	Intention to study weight change	Sample size	Measurements	Results
Bhat et al. ¹³ India	Prospective observational study conducted for 6 m	To determine incidence of significant WL, dehydration, hypernatremia and hyperbilirubinemia in exclusively breastfed, term, healthy neonates and compare incidence in warm versus cool months	No	496 infants of a possible 832 births	Daily weights Birth to discharge (3–8 d) Reports: (1) % infants by WL group Note: significant WL defined as > 10% and/or > 5% in a 24-h period	(1) % infants in WL group: > 10% WL = 06.8% > 05% WL in 24-h period = 24.7% WL considered NS for 68.4% of infants
DeMarzo et al. ¹⁴ United States	Secondary analysis of data	To explore patterns of initial WL and return to BW among healthy, term, breastfed infants and specifically the validity of the clinical criterion of 10% as an acceptable WL	Yes	264 neonates (236 were exclusively breastfed at day 10)	BW, then 1st weight at mean of 5 d and 2nd weight at mean of 10 d Reports: (1) % weight change from BW to 1st weighing, including range, mean, median and SD (2) % infants whose WL exceeded 7% at 1st weighing (3) % infants above BW at 2nd weighing (n = 236)	(1) Range = –14.3 to +15.3% Mean = –1.8% Median = –1.8% SD = 4.2 (2) > 7% WL at ~day 5 (first weighing) = 8.7% of infants (3) Regained BW by 2nd visit = 88.7%
Hossain et al. ⁶ Bangladesh	Prospective observational study conducted for 6 m	To determine postnatal weight change in early neonatal period in relation to gestational age and BW	Yes	48 full-term infants of 185 births (includes 3 low BW babies)	Daily weight until infant regained BW Reports: (1) number of d before beginning to regain weight (2) time in d to regain birth weight	(1) 56.25% began to regain by day 5; 43.75% began to regain by day 10 (2) Regained BW: 1–10 days = 56.16% 11–14 days = 35.41% 15–21 days = 8.33% > 21 days = 2.08%
Jolly et al. ⁷ Jamaica	Prospective	To examine weight change of exclusively breastfed infants through the first 24 d following birth and to evaluate the effect of breastfeeding factors and maternal characteristics on early weight change in the infants	Yes	21 neonates	Weights on day 1 (day of birth) and days 3, 7, 10, 17, 24 Reports: (1) mean and median amounts of weight gained in kg (2) % infants who gained weight on d 3, 7, 24	(1) Change of weight from birth in kg Mean (SEM): Day 3: 0.23 kg (± 0.06) Day 7: 0.56 kg (± 0.09) Day 24: 1.22 kg (± 0.14) Median: Day 3: 0.16 kg Day 7: 0.49 kg Day 24: 1.16 kg (2) % infants who gained: Day 3: 90% Day 7: 95% Day 24: 100%

Table 1 cont'd

Reference	Methodology	Purpose	Intention to study weight change	Sample size	Measurements	Results
Macdonald et al. ¹⁵ Scotland	Prospective observational cohort study	To define the range of neonatal WL in a population relative to feeding method	Yes	937 infants: 45% breastfed (n = 420), 42% formula-fed, 13% combined	<p>Weighted at birth, at discharge (~48 h), ~day 5, 7, 10, 14 (weighing stopped when BW regained)</p> <p>Reports: Median for: (1) % WL (2) timing of maximum WL in d (3) d to regain birth weight (4) percentile data of above</p>	<p>(1) % WL (n = 420): median = 6.6 (6.3–6.9); 95th percentile 11.8 (11.2–12.9)</p> <p>(2) Timing of loss (d) (n = 420): median = 2.7 (2.5–2.8); 95th percentile 9.1 (7.7–10.2)</p> <p>(3) Regain BW (d) (n = 395): median = 8.3 (7.7–8.9); 95th percentile 18.7 (16.7–20.8)</p>
Manganaro et al. ¹¹ Italy	Prospective observational study	To verify the incidence of hypernatremic dehydration in exclusively breastfed, term infants and identify possible maternal and/or infant factors that interfere with successful breastfeeding	No	686 infants of 782 births ≥ 10% WL (n = 53) < 10% WL (n = 633) No supplements first 3 d 26% received formula supplement due to WL (≥ 10%)	<p>Daily weights in hospital and at home on day 5 (vaginal birth) and on day 10 (both vaginal and cesarean)</p> <p>Reports: By group (≥ 10% and < 10% WL): (1) mean % WL and range of % WL for those who lost >/= 10% (2) range of days of maximum WL for type of birth</p>	<p>% subjects: ≥ 10% WL = 7.7% < 10% WL = 82.3%</p> <p>(1) Mean WL ≥ 10% group = 11.3 ± 1.1 (range 10%–14.8%) < 10% group = 5.5 ± 1.2 (no range stated) (2) vaginal: lowest weight at 3–4 d cesarean: lowest weight at 4–5 d</p>
Marchini et al. ¹⁶ Sweden	Prospective observational study	To investigate whether plasma leptin was related to BW or WL during the neonatal period	No	120 infants during first 4 d 4 groups (n = 30 each) according to timing of blood work	<p>Daily weights</p> <p>Reports: (1) % median WL with range</p>	<p>(1) % WL: median (range) Group 1: 3.2 (0.4–5.7) Group 2: 6.0 (2.1–8.2) Group 3: 6.4 (0.1–12.6) Group 4: 5.7 (0.3–15.7)</p>
Martin-Calama et al. ¹² Spain	RCT with control arm of exclusively breastfed infants	To compare the use of glucose water and exclusive breastfeeding on WL, serum glucose level, temperature and breastfeeding duration	No	87 infants in the exclusively breastfed group followed for 72 h	<p>Weights at 6, 12, 24, 48, and 72 h</p> <p>Reports: (1) WL in grams (2) WL as % birth weight</p>	<p>(1) WL: g (SD) 6 h: 46.4 (± 19.1) 12 h: 86.4 (± 30.4) 24 h: 140.6 (± 42.4) 48 h: 197.8 (± 73.2) 72 h: 141.9 (± 89.1)</p> <p>(2) % BW lost 6 h: 1.4% 12 h: 2.6% 24 h: 4.2% 48 h: 5.9% 72 h: 4.2%</p>

Table 1 cont'd

Reference	Methodology	Purpose	Intention to study weight change	Sample size	Measurements	Results
Michel et al. ⁸ France	Prospective descriptive study	To identify incidence and risk factors for breastfeeding difficulties in maternity ward using 3 indicators: excess neonatal WL, delayed onset of lactation, and suboptimal infant breastfeeding behaviour	No	118 infants, of whom 94 were exclusively breastfed 20.3% received formula supplements	Daily weights while in hospital Reports: (1) WL as a mean (2) n that lost < 10%	(1) WL: mean = 6.62 (SD±1.84) in exclusively breastfed infants (shown in text, not table) (2) 3 of 94 (~3%) lost more than 10% (clarified by email)
Muskinja-Montanji et al. ¹⁷ Serbia	Prospective descriptive study	To determine effect of rooming-in on initiation of lactation, and on physiological WL.	No	200 infants: 100 in nursery and 100 in Baby Friendly Hospital Initiative™ (BFHI) hospital (rooming-in)	Daily weights Reports: (1) average WL in g by parity (P) (2) day of lowest weight (3) % of WL by parity	(1) Average WL (g) for nursery / BFHI: P1: 205.00 / 191.70 P2: 178.82 / 171.95 P3: 190.00 / 178.00 (2) Day of lowest weight (combined to form %, n = 200) Day 1: 2 Day 2: 93 Day 3: 90 Day 4: 14 Day 5: 1 (3) % WL by parity for nursery / BFHI: P1 = 6.00% / 5.50% P2 = 5.20% / 5.00% P3 = 5.34% / 5.04% P4 = 7.27% / 5.66%

BW = birth weight; NS = non significant; SEM = standard error of the mean; WL = weight loss; d = day; h = hour; g = gram; kg = kilograms; m = month

Table 2: Examples of studies excluded from systematic review

Reference	Rationale for consideration for abstraction	Study details and reason for exclusion after abstraction
Avoa et al. ¹⁹	Used as reference in clinical practice guideline. Appears to provide information about WL.	Study to determine the effect of a breastfeeding education session provided in labour and delivery on infant WL. Supplemented and "low-birth-weight infants" (not defined) infants are pooled with exclusively breastfed infants.
Benson ²⁰	Title suggests relevant weight data would be part of study.	Study of breastfeeding patterns during first 60 h. No data about weight.
Bystrova et al. ²¹	Abstract says infants were weighed daily as part of study.	Aim was to study effects of different combinations of ward routines: skin-to-skin vs. clothed, rooming-in vs. nursery, and swaddling vs. loosely dressed. Lack of data for weight change patterns of exclusively breastfed infants.
Çağlar et al. ²²	Title suggests primary study about weight loss.	Aim of study was to identify risk factors for WL. No primary data regarding WL.
Dewey et al. ²³	Title and abstract identify neonatal weight loss as a variable.	To determine the incidence of and risk factors for suboptimal infant breastfeeding behavior, delayed onset of lactation, and excess neonatal weight loss. Not all infants were exclusively breastfed.
Livingstone et al. ⁵	Abstract identifies weight loss parameters and normal weight loss is stated on first page of article.	Retrospective study of neonates with hypernatremia. States: "It is normal over the first week of life for the neonate to lose as much as 7% of its birth weight through normal diuresis. Neonates should start to gain weight within a few days and regain their birth weight by the tenth day of life. Either rapid weight loss or loss greater than 7% of birth weight is a cause for concern" (p. 647). No primary data regarding WL. No references or data to support 7% WL limit statement.
Maisels et al. ²⁴	Used as a reference in a CPG.	Compares a group of infants with jaundice (n = 147) with a control group of infants (n=147) randomly chosen from a pool of 2269 healthy infants. States "breastfed infants lost an average of 6.86 ± 2.97% of their birth weight" (p. 508). Only 46.9% were breastfed. Retrospective chart review for data about weight patterns. Insufficient detail about breastfed infants to meet inclusion criteria for systematic review
Merlob ²⁵	Used as a reference in a CPG. Title and abstract indicate topic is about weight loss in the first days following birth	Weight loss on the third day was the criteria for forming study groups to determine predictability for breastfeeding duration. Data about infant weights were not provided
Powers et al. ²⁶	Used as a reference in a CPG.	Clinical information intended for pediatricians. Suggests a weight loss of 8%–10% accompanied by delayed lactogenesis is a possible indication for early supplementation. No primary data regarding weight loss. No references or data to support 8%–10% weight loss limit statement.

Table 2 cont'd

Reference	Rationale for consideration for abstraction	Study details and reason for exclusion after abstraction
Shrago ⁹	Used as a reference in a CPG.	Conference proceeding States: "Normal weight loss in breastfed neonates should not be > 7% of birth weight." Not primary data. Used secondary citations to establish normal weight loss.
Shrago ¹⁰	Abstract states the participants were exclusively breastfed and weighed daily.	Study did not meet definition of "exclusively breastfed." Under methods, authors state, "An infant who received water or glucose water or expressed breast milk was not excluded from the study" (p.197).
Tjon et al. ²⁷	Abstract suggests relevant weight data would be part of study.	Study to determine the percentage of weight lost by Basotho infants following birth and the time to regain birth weight, n = 814 neonates over a 4-year period. Daily weights for up to 7 d or as long as in hospital, reports: 1) mean % of birth weight over 6 d 2) d to regain BW Only 289 of 814 infants were assessed for gestational age. Results included data for pre-term and small-for-gestational-age infants pooled together with data for term infants.
Wright et al. ²⁸	Title suggests relevant weight data would be part of study.	To determine maternal socioeconomic factors that affect infant weight gain or faltering. Only 51% of the neonates were breastfed. Exclusively breastfed data were not reported separately.
Yaseen et al. ²⁹	Used as a reference in a CPG.	To identify the clinical presentation of dehydration related to failure of lactation in exclusively breastfed term infants Control group of 58 healthy, term infants aged 4–7 days. Only 74% of control group were exclusively breastfed, and data were pooled.

infants should begin to gain weight. Health status and the infants' status as singletons or multiples were often not clear; we contacted authors for clarification on these points when necessary. If the subjects were referred to as dyads (i.e., mother and infant) we presumed the neonates to be singletons; we assumed infants to be healthy if they were discharged to home.

Among the 11 studies included in this review, 1 study stands out. The study by MacDonald et al.¹⁵ followed infants for 14 days. The infants were weighed daily while in hospital but intermittently after discharge. The researchers took this factor into account by reporting changes as medians. Based on the results of this study, it appears that weight loss of up to 12% of birth weight is experienced by about 95% of neonates.¹⁵ Within a range, the first day to begin regaining weight is around day 4, and infants regain their birth weight around day nine.¹⁵ Although the longer follow-up period of this study is a strength, the lack of daily weights weakens the findings.

Amount of weight change. Weight loss patterns were described in terms of amount and timing, and the wide range of data descriptions made it difficult to compare or combine study results. In 10 of the 11 included studies, weight change was measured as amounts of weight; the 11th study reported weight patterns based solely on the timing of changes.⁶ In the 10 studies that reported the amounts of weight change, 8 types of descriptive statistics are used to express the amount of weight change: (1) mean weight loss;^{8,11,12,18} (2) median weight loss;^{8,15,16} (3) range of weight change;^{11,14,16} (4) number of subjects over or under a percentage lost;^{11,13,14} (5) amount in grams or kilograms lost or gained;^{7,12,18} (6) percentile data;¹⁵ (7) mean change;¹⁴ and (8) weight change by parity or birth type.¹⁷

Mean weight loss ranged in the studies from 5.7% to 6.6%, with standard deviations hovering around 2% (see Table 1).^{8,11,18} Whether mean percentage represented the average of maximum daily weight loss measurements (i.e., 1 measurement per neonate) or an average of all weights taken is not clear. Manganaro et al.¹¹ divided their subjects into 2 groups (< 10% and ≥ 10%); pooling the results, we determined that the average for the group as a whole was 5.9%. Median percentage weight loss ranged from 3.2% to 8.3%, with the majority of reported medians around 6%.^{8,15,16}

The authors who reported the range of weight change had collected data for 72 hours to 24 days, and the range in these studies varied from a loss of 14.3% to a gain of 15.3%.^{24,26,28} Authors of 3 papers grouped subjects according to the percentage of weight change. For example, DeMarzo et al.¹⁴ report that 8.7% of infants lost more

than 7% of their birth weight, whereas Bhat et al.¹³ found 6.8% lost more than 10% of birth weight, and Manganaro et al.¹¹ found 7.7% lost more than 10% of birth weight. The choice of 7% or 10% for grouping the sample appears to be an arbitrary demarcation for substantial weight loss.

Jolly et al.,⁷ Martin-Calama et al.,¹² and Muskinja-Montanji et al.¹⁷ report the number of kilograms or grams neonates lost or gained. Martin-Calama et al.,¹² describe mean weight losses that peaked at 48 hours, after which mean gains begin. Muskinja-Montanji et al.¹⁷ report weight loss in grams by parity; and the days that most infants lost weight were day 2 and 3. Contrary to the other studies showing weight loss in the first 2 days, Jolly et al.⁷ report substantial weight gains, with 90% of the study infants averaging a gain of 230 grams by the third day.

Three authors were unique in their reporting of weight changes. DeMarzo et al.¹⁴ report the mean change between 2 weights (around day 5 and day 10) measured at post-discharge clinical visits. MacDonald et al.¹⁵ demonstrate the upper limit of weight loss in their study, by stating that the 95th percentile is 11.8%. Rodriguez et al.,¹⁸ in their study of body composition, report average weights for 3 days, but do not provide data about the change.

Timing of weight change. Some of the researchers looked at the day on which the lowest weight (i.e., the nadir) was reached and the day on which neonates regained their birth weight. Five approaches were used to describe the timing of weight change: (1) the day the infants regained their birth weight;^{6,15} (2) the percentage of infants who gained or lost on a particular day;^{13,14} (3) the day of lowest weight;¹⁷ (4) weight change by parity or birth type;¹⁷ and (5) median for both number of days losing weight and days to regain birth weight.¹⁵

In the studies that report the amount of time it took for infants to regain their birth weight, the majority of infants regained their birth weight within the first 2 weeks. Hossain et al.⁶ found 91.57% had regained initial weight by day 14, and DeMarzo et al.¹⁴ state that 88.7% infants were back to birth weight by the second clinic visit (average day 10).

The day of lowest weight is reported by Michel et al.⁸ as day 1 and 2, and by Muskinja-Montanji et al.¹⁷ as day 2 and 3. In each study, the 2 combined days account for about 90% of the sample. The discrepancy seems to be a matter of counting the day of birth as day 0 or day 1 and then the second 24 hours as day 1 or day 2.

Hossain et al.⁶ and Jolly et al.⁷ identify the day infants began to gain weight, with very different results: 56.25% by day 5 and 90% on day 3, respectively. This discrepancy is an outstanding feature; with only 2 studies describing

weight change in this manner, it is difficult to determine which is the outlier.

Two authors have unique methods of reporting. MacDonald et al.¹⁵ report the median number of days of weight loss and the median day to regain birth weight as 2.7 and 8.3 respectively. Manganaro et al.¹¹ note that infants in their study who were born vaginally reached their lowest weight between day 3 and 4, and infants delivered by cesarean section reached their lowest weight between day 4 and 5.

Review of clinical practice guidelines. Clinical practice guidelines (CPGs) are defined as “systematically developed statements [based on best available evidence] to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances.”³⁰ Four key CPGs, among others, were found during searches for this systematic review.^{31–34} Three of the guidelines^{31–33} are about overall breastfeeding, and 1 deals specifically with supplementation.³⁴

These CPGs on breastfeeding advise against supplementation (i.e., replacement breastfeeds) as a standard or casual practice, and they recommend outer limits for weight loss. The American Academy of Pediatrics³¹ states: “Weight loss in the infant of greater than 7% from birth weight indicates possible breastfeeding problems and requires more intensive evaluation of breastfeeding and possible intervention to correct problems and improve milk production and transfer.” The International Lactation Consultant Association³² and the Registered Nurses’ Association of Ontario³³ specify that a loss of more than 7% of birth weight, continued loss after day 3, or failure to regain birth weight within a minimum number of days (i.e., 10 days³⁴ or 2–3 weeks,³³ respectively) are signs of ineffective breastfeeding. The Academy of Breastfeeding Medicine³⁴ advises “Possible indications for supplementation in term, healthy infants [include] weight loss of 8% to 10% accompanied by delayed lactogenesis (day 5 or later).”

These guidelines presume that some weight loss is expected and too much weight loss is a sign of inadequate milk intake due to low milk supply or ineffective milk transfer. The consensus indicates a weight loss in excess of 7% is cause for further assessment and possible intervention. Several of the studies screened for this review are referenced in these CPGs.

Discussion

We found insufficient evidence to answer the question, “What is a normal physiological weight loss for full-term breastfed infants in the first 2 weeks following birth?” We found gaps in relevant data collection and reporting. For

instance, weights were not measured daily after discharge and sample size varied within a report due to attrition.

Two difficulties arise when CPGs propose a single, absolute number as the maximum weight an infant can safely lose. First, an absolute number does not take ranges into account. A recommendation based on observations of a mean loss of 7% of birth weight, assuming such recommendations are derived from samples with normal distributions, needs to take standard deviations into account. For example, a mean weight loss of 6.9% with a standard deviation of 3.07, as Maisels et al.²⁴ report in their study, indicates that about 68% of all infants would experience a weight loss of between 4.0% and 9.8%, and that about 95% of all infants would experience a weight loss of between 1.0% and 12.7%.

Second, when distinguishing a physiological from a pathological weight loss, an absolute number may cause health care professionals to miss red flags. For example, a 3-day-old infant with a 7%–10% weight loss is probably reaching his or her lowest weight before gaining, and this child would be in a different situation than a 9-day-old infant who weighs 10% less than his birth weight. Not only has the 9-day-old infant lost weight, but he or she has not regained and is therefore further behind than the 3-day-old infant. An absolute number in this case is deceptive.

Strengths and limitations of the systematic review. The strengths of this review include adherence to a rigorous methodology. For example, 2 researchers independently completed literature searches and abstractions, and follow-up collaboration ensured that the articles were analyzed multiple times. Our group includes experienced clinicians familiar with current lactation research and the issues involved with breastfeeding (e.g., definition of breastfeeding, significance of supplementation) and experts in statistical analysis.

An important limitation of our study was that our research question did not take into account morbidity and mortality. Given the research question and the inclusion criteria established for this systematic review, no studies were specifically sought to provide evidence suggesting a point, by weight or time measurement, when weight loss presents a health risk. We did find that weight loss did not always have clinical indicators. For example, substantial weight losses were not always paired with hyponatremia.^{11,13,22,29}

Identifying what appears to be a normal weight loss leaves the reader with the question, “So, what if weight loss is outside of normal parameters?” It also became apparent as we analyzed the included studies that not all

weight loss is physiological: there are demographic and iatrogenic factors that affect weight loss, including feeding and non-feeding factors. The research question and the inclusion criteria for articles sought in this systematic review do not illuminate these factors.

Recommendations for further research. Future research should include measures of morbidity and mortality and consider factors affecting weight loss. Morbidity and mortality rates and their relationship to weight loss must be established to determine the point when interventions are required to prevent illness and protect health. Assessment of effective breastfeeding and decisions about supplementation must be based on more than weight loss. The underlying assumption is that weight loss is directly related to inadequate intake, due to either a lack of milk supply or ineffective milk transfer. There appear to be confounding factors (e.g., factors that are not natural or biological imperatives), as evidenced by the variations in mean weight losses.

We found evidence of patterns of weight loss, but we did not identify a relationship with morbidity or mortality. The data we found did not provide information about the implications of a 7% weight loss or a 10% weight loss. Recognizing weight change patterns helps clinicians identify red flags, but assessment cannot stop there. The implications of the weight loss must be understood. Such evidence would ensure that interventions such as supplementation are not based solely on maintaining an infant's weight within pre-established norms.

Research is also needed to determine if weight loss is due solely to inadequate intake. There appears to be iatrogenic weight loss, since we found studies that demonstrate that birthing practices, hospital routines, and birth experiences are associated with the amount of weight lost. Researchers should consider the amount of stooling and voiding that might also contribute to neonatal weight loss. For instance, there is some evidence that infants born to mothers who received IV fluids during parturition experience greater weight loss, and excess neonatal diuresis could be the reason.^{35,36} Studies are needed to understand such factors and how they might affect weight loss.

This systematic review was completed to determine the reference weight loss in the first 2 weeks following birth. Although there is some strong, consistent evidence regarding weight loss patterns in the first few days, the results of our systematic review suggest that further questions need to be answered before a normal range for neonatal physiological weight loss can be established and indications for interventions can be determined.

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